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1 Introduction

The Relativistic Heavy-Ion Collider (RHIC) at Brookhaven National Laboratory was designed to study the properties of quantum chromodynamics (QCD) in a hot and dense medium. The first years of RHIC operation and accompanying theoretical studies have helped pinpoint certain classes of measurements needed to more fully probe the medium and determine its properties. The medium created in these heavy-ion (AA) collisions appears to thermalize quickly and exhibits collective flow patterns consistent with hydrodynamic predictions. The initial temperature of the medium is not known and it is not yet understood whether deconfinement and chiral symmetry restoration are realized during its evolution. The answers to these questions require higher luminosities and detector upgrades, referred to as RHIC-II. The goal of RHIC II is to achieve the answers to the above questions by increasing the ion luminosity.

The measurements thus far at RHIC could not fully address these fundamental questions, either due to incomplete detection capabilities or insufficient statistics to draw meaningful and robust conclusions. Working groups were formed to determine which physics topics could best be addressed by the combination of planned upgrades and increased luminosity. Reports from each working group were used to prepare a white paper for RHIC II, along with additional inputs from the conveners of all working groups.

Heavy flavor and electromagnetic probes were identified as particularly benefiting from improved detector and accelerator performance. These probes are also ideally suited for answering the key physics questions.

Tantalizing heavy flavor data has already been taken at RHIC, including direct reconstruction of D^0 mesons by STAR, single electrons from semileptonic decays of charm and bottom hadrons by both STAR and PHENIX, and detailed J/ψ measurements from PHENIX. However, these data are not sufficient to obtain definitive answers to the fundamental questions in this sector. Direct reconstruction of hadronic decays of other charm and bottom hadrons is desirable, particularly since it is not possible to easily disentangle the individual charm and bottom contributions from single electron measurements alone. The total charm cross sections obtained by STAR and PHENIX remain inconsistent. In addition, cold nuclear matter effects on J/ψ production need to be better quantified to reliably interpret the AA data. Measurements of χ_c and ψ' production are required to clarify the feed down contributions to inclusive J/ψ production. Preliminary Υ measurements, when supplemented with higher statistics data, will complement the J/ψ results and shed light on the question of J/ψ regeneration by coalescence, as will a precise determination of the J/ψ elliptic flow.

In the electromagnetic sector, the first direct photon measurements are consistent with initial temperatures estimated from hydrodynamic models. More precise data are essential for a direct temperature "measurement". The latter can be complemented and checked by photon-photon correlation data as well as with dilepton spectra at intermediate mass and momentum. The dilepton signal in this regime is especially influenced by correlated heavy-flavor decays, emphasizing the importance of a precise assessment of the medium modifications of open heavy-flavor hadrons and their associated spectra. The prime observable for studies of chiral symmetry restoration, to determine electromagnetic spectral functions close to the QCD phase boundary, are low-mass dilepton spectra, presumably dominated by ρ^0 decays. Both STAR and PHENIX detector upgrades will be instrumental in achieving the precision required to extract evidence for chiral restoration – in concert with theoretical (and possibly experimental) studies of the axial-vector, a_1, spectral function, the chiral partner of the ρ^0. High luminosities will be essential to conduct systematic studies of excitation functions. A possible window on resonance structures in the quark-gluon plasma could be provided by high precision intermediate-mass dilepton spectra, in particular in connection with transverse momentum spectra.

The above considerations emphasize that the PHENIX and STAR detector upgrades make it possible to more completely detect the desired probes, such as better reconstruction of charm and bottom hadrons rather than relying on single electron measurements where the parent hadron is unidentified. The luminosity upgrade will provide higher statistics measurements of *e.g.* low mass dileptons to distinguish between models of chiral symmetry restoration. It will also make statistically significant measurements of Υ production possible.

This report combines updated version of the heavy flavor and electromagnetic RHIC II working group reports. It documents the current state of RHIC theory and data for these probes and describes what will be achievable with the currently planned detector and luminosity upgrades.

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